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Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Jaime Nickeson, Editors

Volume 55 BOREAS RSS-8 BIOME-BGC SSA Simulations of Annual Water and Carbon Fluxes

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National Aeronautics and Space Administration

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BOREAS RSS-8 BIOME-BGC SSA Simulations of Annual Water and Carbon Fluxes

John S. Kimball

Summary

The BOREAS RSS-8 team performed research to evaluate the effect of seasonal weather and landcover heterogeneity on boreal forest regional water and carbon fluxes using a process-level ecosystem model, BIOME-BGC, coupled with remote sensing-derived parameter maps of key state variables. This data set contains derived maps of landcover type and crown and stem biomass as model inputs to determine annual evapotranspiration, gross primary production, autotrophic respiration, and net primary productivity within the BOREAS SSA-MSA, at a 30-m spatial resolution. Model runs were conducted over a 3-year period from 1994-1996; images are provided for each of those years. The data are stored in binary image format.

Note that some of the data files on the BOREAS CD-ROMs have been compressed using the Gzip program. See Section 8.2 for details.

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1. Model Overview

1.1 Model Identification

BOREAS RSS-08 BIOME-BGC SSA Simulations of Annual Water and Carbon Fluxes

1.2 Model Introduction

The Biome Biogeochemistry Model (BIOME-BGC) simulates biogeochemical and hydrologic processes across multiple biomes based on the logic that differences in process rates between biomes are primarily a function of climate and general life form characteristics. BIOME-BGC uses daily meteorological data in conjunction with general stand and soil information to predict components of the hydrologic budget (e.g., transpiration, evaporation, snowcover, soil water, runoff) and carbon budget

(e.g., net photosynthesis, autotrophic and heterotrophic respiration) at a daily time-step. BIOME-BGC is general in the sense that the surface is represented by singular, homogeneous canopy and soil layers. Detailed descriptions of BIOME-BGC logic are given by Running and Coughlan [1988] and Running and Hunt [1993]. Model descriptions relating to the prediction of carbon and hydrologic processes within the BOReal Ecosystem-Atmosphere Study (BOREAS) region are given by Kimball et al. [1997a,b; 1998].

1.3 Objective/Purpose

The purpose of this investigation is to assess the effects of boreal forest interannual weather variability and landcover heterogeneity on regional water and carbon flux simulations using BIOME-BGC. Remote sensing-derived maps of landcover type and crown and stem biomass were used as model inputs to determine regional evapotranspiration (ET), net primary production (NPP), gross primary production (GPP), and autotrophic respiraton (R) within the BOREAS Southern Study Area (SSA) Modeling Sub-Area (MSA). Model simulations were conducted using input data at a 30-m spatial scale. These results are used to investigate the importance of subgrid scale landcover variability on regional biogeochemical processes over a 3-year period, from 1994 to 1996.

1.4 Summary of Parameters

Model Daily Input Requirements:

BIOME-BGC uses a spatial data base composed of soil, vegetation, and daily meteorological characteristics registered to a common projection format, as well as an array of critical physiological constants that define the environmental response curves of individual biome types within the spatial domain (see Kimball et al. [1997a,b; 1998]). Remote sensing-derived crown and stem biomass and landcover classification maps were used to drive model simulations within the SSA-MSA. More detailed information regarding remote sensing and stand biophysical inputs is provided in Section 5.

BIOME-BGC uses daily maximum and minimum air temperatures, solar irradiance (direct + diffuse), and precipitation to determine daily carbon and water fluxes. Daily meteorological data were interpolated over a 1-km-resolution digital elevation map (DEM) of the SSA-MSA using a daily meteorological interpolator [Running et al., 1987; Thornton et al., 1997], digital elevation information (i.e., elevation, slope, aspect), and daily meteorological data from approximately 60 weather stations within the BOREAS region. Gridded daily meteorological data were produced for the 3-year (1994-96) study period.

Model Outputs:

BIOME-BGC determines water and carbon components on a daily basis. The maps provided in this data set represent annual accumulations of daily results. NPP represents the net accumulation of carbon by the stand and is determined as the daily difference between gross photosynthesis and respiration from autotrophic (R) and growth respiration processes. GPP represents the total gain of carbon to the system by net photosynthesis and is defined as the daily sum of gross photosynthesis and daily foliar respiration. R represents the total loss of carbon from the system due to day and night foliar respiration and sapwood, coarse root, and fine root respiration components. ET is computed as the daily sum of transpiration and evaporation from surface, snow, and canopy components.

1.5 Discussion

Since its inception as a point-scale model, BIOME-BGC has evolved to simulate regional scale processes by incorporating spatially distributed daily meteorological fields derived from a microclimate simulator, and remote sensing-derived surface parameter maps to define important landscape characteristics. The model uses a biome-level stratification of landcover conditions to minimize spatial variability in conversion efficiencies and potential environmental controls. For landscape simulations, BIOME-BGC uses a spatial data base composed of soil, vegetation, and daily meteorological characteristics registered to a common projection format, as well an array of critical physiological constants that define the environmental response curves of individual biome types within the spatial domain (see Kimball et al. [1997a,b; 1998]). These physiological constants were obtained from

BOREAS field measurements when possible. When these data were unavailable, values were selected from the literature for representative cover types under similar environmental conditions. For more detailed information regarding the extraction of model inputs, see Section 5.

1.6 Related Models

BIOME-BGC represents the evolution of a forest ecosystem process model (FOREST-BGC) to include biophysical representations of additional growth forms and biome characteristics. Descriptions of FOREST-BGC are provided by Running and Coughlan [1988], while descriptions of BIOME-BGC development and logic are provided by Running and Hunt [1993]. BIOME-BGC and FOREST-BGC models have also been coupled with remote sensing and gridded daily microclimate information to assess ecological processes at landscape and global scales [Kimball et al., 1998; Pierce et al., 1994; Running et al., 1987, 1989].

Other BOREAS data sets related to this are:

BOREAS TE-06 NPP for the Tower Flux, Carbon Evaluation, and Auxiliary Sites BOREAS TE-09 NSA Canopy Biochemistry BOREAS TE-09 NSA Photosynthetic Response Data BOREAS TE-18 Landsat TM Maximum Likelihood Classification Image of the SSA BOREAS TE-18 Landsat TM Physical Classification Image of the SSA

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Steven W. Running Dr. John S. Kimball

2.2 Title of Investigation

BIOME-BGC Regional Simulations of Annual Water and Carbon Fluxes within the BOREAS SSA-MSA

2.3 Contact Information

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3. Theory of Measurements

See documentation for Remote Sensing Science (RSS)-16, Terrestrial Ecology (TE)-18, TE-09, and TE-06 data sets referenced within.

4. Equipment

Not applicable.

5. Data Acquisition Methods

Crown and stem biomass and landcover classification maps derived from remote sensing were used to drive model simulations within the SSA-MSA. Crown and stem biomass maps were derived from 1994 airborne synthetic aperture radar (AIRSAR) remote sensing measurements of the SSA-MSA collected from a DC-8 aircraft [Sellers and Hall, 1994; Saatchi and Rignot, 1997]. A landcover classification map of the SSA-MSA was also obtained from AIRSAR data collected during the 1994 growing season [Saatchi and Rignot, 1997]. These maps are currently available from the BOREAS RSS-16 team. A second landcover classification map, derived from 1994 Landsat Thematic Map (TM) information, was obtained from the BOREAS TE-18 team and was used to distinguish broadleaf deciduous stands within areas defined as mixed forest within the AIRSAR landcover classification.

The RSS-16 landcover classification maps were used to define the number of individual biome types represented in the ecosystem model, while RSS-16 biomass maps were used to define leaf area index (LAI) and foliar and stem carbon pools within each grid cell. The classification map was used to distinguish six landcover classes within the SSA-MSA, representing dry conifer, wet conifer, open water, disturbed, mixed deciduous/conifer forest, and wetland areas. Dry conifer areas were mainly composed of jack pine stands while wet conifer areas consisted mainly of black spruce stands. Wetland areas were composed of a mixture of black spruce, bog, and fen sites, while disturbed sites represented a mixture of recently logged and burned areas, roads, and other sparsely vegetated and nonwater surfaces. Mixed deciduous/conifer forest areas represented a mixture of aspen forest and mixed jack pine/aspen forest with no clear dominance of either species type. Our analysis focused on vegetated areas within the SSA-MSA only. Open water areas were not represented in the model and were masked from further analysis.

The mass of living stem carbon was derived from the RSS-16 AIRSAR stem biomass map and estimates of the relative proportions of living and total stem biomass, and the proportions of living cells in sapwood tissue. This information was obtained from BOREAS TE-06 team's biomass harvest plots within the SSA-MSA and information reported in the literature for representative vegetation types [Gower et al., 1997; Waring and Running, 1998]. The mass of living coarse root carbon was estimated as a proportion of live stem carbon using allometric relationships for representative cover types [Grier et al., 1981; Vogt, 1991; Steele et al., 1997]. The mass of living fine root carbon was estimated from 1.5 to 3.0 times foliar carbon estimates based on SSA-MSA biomass measurements and information reported in the literature for nutrient-limited arctic, boreal, and cold temperate environments [Bigger and Oechel, 1982; Mitsch and Gosselink, 1993; Schimel et al., 1996; Gower et al., 1997; Steele et al., 1997].

The mass of foliar carbon was derived from the RSS-16 AIRSAR crown biomass (i.e., leaves and branches) map and estimated proportions of foliar to crown biomass obtained from the TE-06 biomass harvest plots within the SSA-MSA [Gower et al., 1997]. LAI was derived from foliar carbon maps and specific leaf area (SLA) values obtained from canopy biophysical measurements within the SSA-MSA collected by team TE-09 [Dang et al., 1997b]. The LAI for coniferous vegetation was held constant over each year. For deciduous vegetation, LAI was regulated between a prescribed seasonal minimum (i.e., 0.0) and the remote sensing-defined seasonal maximum using a phenology model based on daily meteorological predictions of satellite-observed dates of greenness onset and offset

[White et al., 1997]. The model predicts the onset of greenness using a combined thermal and radiation summation, while offset is determined using a thermally adjusted photoperiod trigger. The foliar carbon pool was increased on a daily basis using a stepped 45-day linear ramping function between the onset date and the RSS-16 AIRSAR-derived LAI, while foliage drop occurred at the offset date.

Foliar leaf nitrogen concentrations strongly influence the photosynthetic capacity of the system and are directly related to the amount of radiation absorbed by the canopy [Pierce et al., 1994]. Because canopy absorption is also related to LAI, foliar nitrogen was estimated as a proportion (0.7-4.5%) of leaf carbon. These fractions were derived from TE-09 site measurements within BOREAS aspen, jack pine and black spruce stands [Dang et al., 1997b; Sullivan et al., 1997] and values reported in the literature for representative cover types [Aerts et al., 1992; Mitsch and Gosselink, 1993; Schimel et al., 1996].

Soil rooting depth and water holding capacity information were derived from a 1:1,000,000-scale digital soils inventory data base of Canada obtained through BOREAS staff from the Land Resource Research Centre of Agriculture Canada [Acton et al., 1991] and volumetric soil moisture and soil survey measurements conducted at several sites within the SSA by the BOREAS Hydrology (HYD)-01 team [Sellers and Hall, 1994; Cuenca et al., 1997]. Soil b-parameter values define the slope of the functional soil water potential (j) response to changes in soil water and were derived from values reported in the literature for representative soil types [Cosby et al., 1984]. Soil structural characteristics were assumed constant within the area represented by each landcover class.

Daily meteorological data were interpolated over a 1-km-resolution DEM of the SSA-MSA using a daily meteorological interpolator [Running et al., 1987; Thornton et al., 1997], digital elevation information (i.e., elevation, slope, aspect), and daily weather data from approximately 60 stations within the BOREAS region. Gridded daily meteorological data were produced for the 3-year (1994-96) study period. The meteorological data were obtained from the National Climatic Data Center's Global Surface Summary of the Day data base, the Saskatchewan Research Council's Automatic Meteorological Stations data base, and BOREAS tower flux site measurements within the SSA-MSA [National Weather Service, 1988; Sellers and Hall, 1994; Shewchuk, 1997]. DEM information was provided by the BOREAS HYD-08 team and BOREAS staff [Sellers and Hall, 1994].

Daily model simulations were conducted for the BOREAS SSA-MSA study region from 01-Jan-1994 to 31-Dec-1996. Meteorological conditions were defined using the 3-year gridded daily meteorological fields, while 1994 landcover type and biomass maps defined surface physical conditions for the 3-year period. Spatially distributed estimates of initial soil water and snow water equivalent depth were required to initialize the 1994 water balance. The model was initialized with a uniform snow water equivalent depth of 3.3 cm and a soil water depth set at 95% of field capacity. These values were determined from BIOME-BGC point simulations at BOREAS SSA-MSA tower sites using 1993 daily meteorological data from Nipawin Airport (53.20N 104.00W) near the SE corner of the SSA-MSA.

Deciduous and coniferous canopies within mixed cells were simulated separately because of marked differences in biophysical characteristics and physiological responses to environmental controls. Dry and Wet Conifer classes were assumed to be composed entirely of coniferous vegetation. Disturbed, mixed conifer/deciduous, and wetland classes were represented as a mixture of 50% deciduous and 50% coniferous lifeforms. Landcover classification information derived from Landsat TM data was used to distinguish broadleaf deciduous stands (see above) within AIRSAR-defined mixed conifer/deciduous areas. These areas were assumed to be 100% deciduous, while other mixed conifer/deciduous areas were represented as a mixture of 50% coniferous and 50% deciduous. Ideally, information on deciduous and coniferous proportional cover characteristics could be used to simulate the relative contributions of different lifeforms to the total water and carbon flux within each grid cell. Unfortunately, that information was not available for this investigation and thus simplifying assumptions were necessary.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

Not applicable.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The image files cover the entire area within the BOREAS SSA-MSA (approximately 40 km x 50 km). However, model runs were limited by the extent of available AIRSAR data; unknown and open water landcover classes were also masked from model analyses so that the actual size of the simulated surfaces represent a smaller area of approximately 1200 km². Model results were generated with a minimum pixel size of 30 m, which represents the spatial resolution of the AIRSAR data. The coordinates of the upper-left corner of the upper-left pixel are (North American Datum of 1983 (NAD83)):

		UTM	UTM
Longitude	Latitude	Easting	Northing
105.46023° W	54.28602° N	470039.5	6015442.5

7.1.2 Spatial Coverage Map

None.

7.1.3 Spatial Resolution

The spatial resolution of the images is 30 m x 30 m.

7.1.4 Projection

The area mapped is projected in the ellipsoidal version of the Albers Equal Area Conic (AEAC) projection. The projection has the following parameters:

Datum: NAD83

Ellipsoid:

GRS80 or WGS84
111.000° West longitude Origin:

51.000° North latitude

Standard Parallels: N 52° 30' 00"

N 58° 30' 00"

Units of Measure: kilometers

7.1.5 Grid Description

The data are gridded in 30 m intervals based on projection described in Section 7.1.4.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

The images represent annual accumulations of daily model results for 1994, 1995, and 1996.

7.2.2 Temporal Coverage Map

None.

7.2.3 Temporal Resolution

The images represent annual accumulations of daily model output.

7.3 Input Data Characteristics

7.3.1 Input Parameter/Variable

See Section 1.4.

7.3.2 Variable Description/Definition

See Section 1.4.

7.3.3 Unit of Measurement

See Section 1.4.

7.3.4 Data Source

See Section 1.4.

7.3.5 Data Range

See Section 1.4.

7.4 Output Data Characteristics

7.4.1 Output Parameter/Variable

GPP, NPP, R, ET.

7.4.2 Variable Description/Definition

See Section 1.4.

7.4.3 Unit of Measurement

GPP, NPP and R (kg C/m²/yr). ET (kg/m²/yr).

7.4.4 Data Source

GPP, NPP, R, and ET images represent annual accumulations of BIOME-BGC daily output.

7.4.5 Data Range

Not applicable.

7.5 Sample Data Records

Not applicable.

8. Data Organization

8.1 Data Granularity

The smallest unit of data is the complete set of simulated images described in this document.

8.2 Data Format(s)

8.2.1 Uncompressed Files

This data set contains the following 13 files:

file	description			
1	Evapotranspiration 1994			
2	Gross Primary Production 1994			
3	Net Primary Production 1994			
4	Autotrophic Respiration 1994			
5	Evapotranspiration 1995			
6	Gross Primary Production 1995			
7	Net Primary Production 1995			
8	Autotrophic Respiration 1995			
9	Evapotranspiration 1996			
10	Gross Primary Production 1996			
11	Net Primary Production 1996			
12	Autotrophic Respiration 1996			
13	AIRSAR-derived Landcover 1994			

The first 12 files contain three years of model output of ET, GPP, NPP, and R for 1994, 1995, and 1996. File 13 is the AIRSAR-based landcover image of 1994. Files 1-12 contain 1120 logical records (lines), each 3000 bytes long. Each line for these 12 files contain 1500 2-byte values (pixels), for a total of 3000 bytes in each of 1120 lines. File 13 is a single-byte image and thus has just 1500 bytes (pixels) in each of the 1120 lines.

BIOME-BGC output image data are presented as binary image maps of annual ET, GPP, NPP, and R. As stored, the values are scaled integers that can be converted to physical units by using the following equations:

```
GPP, NPP and R (kg C/m^2/yr) = (DN/1000)-5 ET (kg/m<sup>2</sup>) = (DN/10)-1
```

The six-class landcover image (used for the model simulations) is a single-byte image. This image was extracted from the RSS-16 AIRSAR landcover map [Saatchi and Rignot, 1997]. This image is spatially equivalent to the BIOME-BGC output images. Landcover values correspond to the following landcover types: 0 = Unknown, 1 = Dry conifer, 2 = Disturbed, 3 = Water, 4 = Wet conifer, 5 = Mixed forest, 6 = Fen/Wetland.

The size of the modeling area was governed by the extent of available AIRSAR data used to provide landcover information. Unknown and open water landcover classes were masked from model analyses. Similarly, areas outside the bounds of available AIRSAR coverage were also masked. Masked pixels are designated with a missing data "-9999.0" flag.

8.2.2 Compressed CD-ROM Files

On the BOREAS CD-ROMs, the image files have been compressed with the (Gzip) GNU zip compression program (file_name.gz, version 1.2.4, using the high compression (-9) option (Copyright (C) 1992-1993 Jean-loup Gailly). Gzip uses the Lempel-Ziv algorithm (Welch, 1994) also used in the zip and PKZIP programs. The compressed files may be uncompressed using gzip (with the

-d option) or gunzip. Gzip is available from many Web sites (for example, the ftp site prep.ai.mit.edu/pub/gnu/gzip-*.*) for a variety of operating systems in both executable and source code form. Versions of the decompression software for various systems are included on the CD-ROMs.

9. Data Manipulations

9.1 Formulae

See Kimball et al. [1997a,b; 1998].

9.1.1 Derivation Techniques and Algorithms

See Kimball et al. [1997a,b; 1998].

9.2 Data Processing Sequence

9.2.1 Processing Steps

BOREAS Information System (BORIS) staff copied the American Standard Code for Information Interchange (ASCII) and compressed the binary files for release on CD-ROM.

9.2.2 Processing Changes

None given.

10. Errors

10.1 Sources of Error

BIOME-BGC is a process-level model designed to be general enough to apply at regional to global scales. The model uses several simplifying assumptions regarding stand and meteorological conditions in order to facilitate application at regional scales. A fundamental model assumption for this investigation was that stand physiological conditions such as age, stand structure, and carbon storages were spatially and temporally uniform on an annual basis. Soil conditions such as rooting depth, density, and moisture content were also assumed spatially uniform with no lateral or subsurface drainage.

Stand conditions at the study sites were both spatially and temporally diverse and were composed of different age types, biomass densities, and species compositions (BOREAS Science Team, 1995). Some sites also had significant vegetation understories that were not explicitly modeled in this investigation. Recent research indicates that understory processes can contribute significantly to annual carbon and water budgets. Other factors such as stand disease and mortality effects and soil nutrient variability were also not addressed. Although much of the boreal forest is relatively flat, subgrid scale variability in precipitation, wind, solar irradiance, albedo, and the surface energy balance may induce greater heterogeneity in surface fluxes than we were able to distinguish using a 1-km gridded daily meteorological data base and a 30-m landcover data base. Other major uncertainties include the relative proportions of deciduous and coniferous vegetation within each landcover class and amounts of fine and coarse root biomass for different stands. These factors strongly influence stand environmental response curves and respiration rates but are difficult to quantify from available BOREAS data. Further discussion of potential error sources for this investigation is given by Kimball et al. [1997 a,b; 1998].

10.2 Quality Assessment

10.2.1 Model Validation by Source

Modeled AIRSAR-derived landcover, biomass, and LAI inputs have been compared with similar results derived from optical remote sensing data, surface optical LAI, and biomass measurements

(e.g., Saatchi and Rignot, 1997). Model outputs have been compared with tower flux site daily water and CO_2 flux estimates, as well as soil water, snowcover, and biomass allometric measurements (e.g., Kimball et al., 1997a,b). Annual 1994 NPP results averaged approximately 2.7 (\pm 0.4), 3.4 (\pm 0.3), 1.9 (\pm 0.3), 2.1 (\pm 0.3), 1.0 (\pm 0.5), and 2.0 (\pm 0.6) Mg C/ha/yr for wetland, mixed conifer/deciduous, dry and wet conifer, disturbed, and broadleaf deciduous stands, respectively. These values were approximately 24% (NPP) smaller for 1995 and 1996 in response to cooler spring and warmer, drier summer conditions. Simulated ranges and landcover differences in NPP were similar to observations reported by other investigators using above- and below-ground biomass measurements and allometric relationships within SSA black spruce, jack pine, and aspen stands [Gower et al., 1997; Steele et al., 1997]. NPP observation data for fen and other wetland areas were not available within the SSA-MSA. However, model simulations were similar to the magnitudes and ranges of NPP (above-ground only) reported in the literature for northern bog marshes, rich fen, forested peatland, and fen forest sites within Canada and the northern U.S.; reported values range from 0.5-9.7 Mg C/ha/yr [Mitsch and Gosselink, 1993].

Annual 1994 ET results averaged approximately 23.3 (± 1.7), 23.7 (± 1.7), 21.4 (± 1.6), 24.6 (± 2.1), 19.3 (± 0.3), and 22.3 (± 0.7) cm/yr for wetland, mixed conifer/deciduous, dry and wet conifer, disturbed, and broadleaf deciduous stands, respectively, and decreased from 0.04-5.6% for 1995 and 1996. The magnitudes and relative differences in ET between landcover classes were similar to 1994 cumulative ET estimates obtained from tower eddy-flux measurements at SSA black spruce [Jarvis et al., 1997], jack pine [Baldocchi et al., 1997], and aspen sites [Black et al., 1996]. Earlier comparisons between model results and field measurements at individual tower sites showed that model results explained approximately 62 and 98 percent of the respective variances in observed daily ET and soil water [Kimball et al., 1997b].

10.2.2 Confidence Level/Accuracy Judgment

See Sections 10.1 and 10.2.1.

10.2.3 Measurement Error for Parameters

See Sections 10.1 and 10.2.1.

10.2.4 Additional Quality Assessments

See Sections 10.1 and 10.2.1.

10.2.5 Data Verification by Data Center

BORIS staff viewed the imagery to verify image size and type and to establish data ranges.

11. Notes

11.1 Limitations of the Model

See Section 12.

11.2 Known Problems with the Model

See Section 10.1.

11.3 Usage Guidance

See Sections 10.1 and 12. Before uncompressing the Gzip files on CD-ROM, be sure that you have enough disk space to hold the uncompressed data files. Then use the appropriate decompression program provided on the CD-ROM for your specific system.

11.4 Other Relevant Information

See Section 12.

12. Application of the Model

These data represent research in progress. We expect our results to improve as existing data sets improve and additional remote sensing parameter maps and measurement data regarding stand and soil morphology become available. These results are intended for visual interpretation, assessment of yearly variations in annual fluxes, and comparison with other models and additional measurement data.

13. Future Modifications and Plans

This model will be coupled with gridded daily meteorological data, soil, and remote sensing parameter maps (e.g., landcover, LAI, radar freeze-thaw) to generate landscape-level estimates of water and carbon exchange processes over the 1 x 106 km² BOREAS grid at a 1-km spatial resolution. There are currently no plans to generate further high-resolution (30 m) results.

14. Software

14.1 Software Description

FOREST-BGC is currently available in C format and can be obtained via ftp download. BIOME-BGC is still under development and is not available for public release at this time. Gzip (GNU zip) uses the Lempel-Ziv algorithm (Welch, 1994) used in the zip and PKZIP commands.

14.2 Software Access

The Numerical Terradynamic Simulation Group (NTSG) Web site (see Section 2.3) currently provides software updates and download information on model changes and availability (web site: http://www.forestry.umt.edu/ntsg/). Gzip is available from many Web sites across the Internet (for example, FTP site prep.ai.mit.edu/pub/gnu/gzip-*.*) for a variety of operating systems in both executable and source code form. Versions of the decompression software for various systems are included on the CD-ROMs.

14.3 Platform Limitations

The FOREST-BGC family of models has been written and compiled on UNIX AIX platforms but should compile with any standard C compiler (web site: http://www.forestry.umt.edu/ntsg/).

15. Data Access

The BIOME-BGC SSA simulations are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services Oak Ridge National Laboratory P.O. Box 2008 MS-6407 Oak Ridge, TN 37831-6407 Phone: (423) 241-3952

Fax: (423) 574-4665

E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

The data can be made available on 8-mm or Digital Archive Tape (DAT) media.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

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17.3 Archive/DBMS Usage Documentation None.

18. Glossary of Terms

None.

19. List of Acronyms

AEAC - Albers Equal-Area Conic

AIRSAR - Airborne Synthetic Aperture Radar

ASCII - American Standard Code for Information Interchange

BIOME-BGC - Biome Biogeochemistry Model

BOREAS - BOReal Ecosystem-Atmosphere Study

BOREAS - BOREAI ECOSYSTEM ACMOSPHETE SERVEY

BORIS - BOREAS Information System

CD-ROM - Compact Disk-Read-Only memory

DAAC - Distributed Active Archive Center

DAT - Digital Archive Tape

DEC - Broadleaf deciduous landcover

DEM - Digital elevation model

- Digital Number (scaled binary image value)

DN DSTRB - Disturbed landcover EOS - Earth Observing System
EOSDIS - EOS Data and Information System
ET - Evapotranspiration (kg/m²)

- Geographic Information System GIS

GPP - Gross Primary Production or net photosynthesis (kg C/m²)

GSFC - Goddard Space Flight Center

Gzip - GNU zip

- Leaf Area Index (m²/m²) LAI

MSA - Modeling Sub-Area

NAD83 - North American Datum of 1983 NASA - National Aeronautics and Space Administration

- Net Primary Production (kg C/m²)

NSA - Northern Study Area

- Numerical Terradynamic Simulation Group NTSG

ORNL - Oak Ridge National Laboratory - Prince Albert National Park PANP

- Autotrophic or maintenance respiration (kg C/m²) R

 Remote Sensing Science
 Specific Leaf Area (m²/kg C) RSS SLA

SSA - Southern Study Area - Terrestrial Ecology TM- Thematic Mapper

URL - Uniform Resource Locator

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Kimball, J.S., P.E. Thornton, M.A. White and S.W. Running. 1997b. Simulating forest productivity and surface-atmosphere carbon exchange in the BOREAS study region. Tree Physiol., 17, 589-599.

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13. ABSTRACT (Maximum 200 words)

The BOREAS RSS-8 team performed research to evaluate the effect of seasonal weather and landcover heterogeneity on boreal forest regional water and carbon fluxes using a process-level ecosystem model, BIOME-BGC, coupled with remote sensing-derived parameter maps of key state variables. This data set contains derived maps of landcover type and crown and stem biomass as model inputs to determine annual evapotranspiration, gross primary production, autotrophic respiration, and net primary productivity within the BOREAS SSA-MSA, at a 30-m spatial resolution. Model runs were conducted over a 3-year period from 1994-1996; images are provided for each of those years. The data are stored in binary image format.

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